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14. ABSTRACT

Unmanned aerial vehicles (UAVs) have proven to be an integral tool for the operational commander as a provider of persistent intelligence, surveillance and reconnaissance (ISR). UAVs are essential for conducting and executing modern military operations. They address a small force-to-space ratio problem by increasing the speed of the kill chain. UAV technology applications have progressed from ISR to an ever expanding list of uses. There is an overarching USN plan for UAVs, but I propose an emphasis should be placed on the close range or tactical UAVs that will directly complement battle space management, increase situational awareness and will increase the flexibility and capability of the kill chain for operational level commanders. Tactical UAVs will assist with gaining and sharing battle force access for naval and joint forces. They will increase the on-demand capability to gain ISR information and allow the flexibility to project power. The USN needs a better road map for tactical UAVs to exploit emerging capabilities and utilize them in maritime roles which will ensure Maritime Domain Awareness.

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THE WAY AHEAD FOR MARITIME UAVS

by

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

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Abstract

Unmanned aerial vehicles (UAVs) have proven to be an integral tool for the operational commander as a provider of persistent intelligence, surveillance and reconnaissance (ISR). UAVs are essential for conducting and executing modern military operations. They address a small force-to-space ratio problem by increasing the speed of the kill chain. UAV technology applications have progressed from ISR to an ever expanding list of uses. There is an overarching USN plan for UAVs, but I propose an emphasis should be placed on the close range or tactical UAVs that will directly complement battle space management, increase situational awareness and will increase the flexibility and capability of the kill chain for operational level commanders. Tactical UAVs will assist with gaining and sharing battle force access for naval and joint forces. They will increase the on-demand capability to gain ISR information and allow the flexibility to project power. The USN needs a better road map for tactical UAVs to exploit emerging capabilities and utilize them in maritime roles which will ensure Maritime Domain Awareness.

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INTRODUCTION

Unmanned aerial vehicles (UAVs) are not new to the arsenal of intelligence, surveillance and reconnaissance (ISR) assets employed by U.S. armed forces. The constant improvements in technology have allowed increases in persistence and longer endurance for an increasingly demanded asset by all units and commanders from the tactical, operational and to the strategic levels of leadership. UAV operations have proven essential for conducting and executing modern military operations by addressing a small force-to-space ratio by increasing the speed of the kill chain. Technology applications have progressed from ISR to an ever expanding list of uses. Brigadier General E.J. Sinclair, Commanding General of the Army Aviation Center said, “We quite honestly don’t know where we’re going with these UAVs.”[1] Where will the U.S. Navy go? The proper development of maritime UAV employment strategy will greatly enhance the USN contribution to the joint effort and assist in securing Global Maritime Domain Awareness. Persistent ISR capability has been considered as a prerequisite for the U.S. Navy’s UAV plan. The USN has a solid grasp on the larger-payload and longer-endurance UAVs.[2] There are numerous development programs under way, but there is no finite guidance for the smaller UAV systems. The lack of guidance allows some creativity with no definite bounds to stay within, yet a plan is needed to ensure the USN has a vision for their future tactical UAVs. Smaller tactical UAVs hold many potential capabilities that if shaped properly, could enhance current missions and fill roles and missions of the future. I propose an emphasis should be placed on the close range or tactical UAVs that will directly complement battle space management, increase situational awareness and will increase the flexibility and capability of the kill chain for operational level commanders.

Current USN UAV Plan

The USMC has a tiered UAV program consisting of designated requirements with increasing size, range and capabilities. Each tier moves from simple ISR in Tier I to more capable electro-optic (EO) and infrared (IR) systems in Tier II to communications relay and weapons employment capability in Tier III. [3] The current US Naval Unmanned Aircraft System Road Map under the Broad Area Maritime Surveillance (BAMS) concept has four levels that I will label as levels I through IV. The USN has not yet designated finite criteria for Levels I and II except for terming them small tactical and tactical UAVs respectively. In reality, this may be to their benefit as it will allow more flexibility and we may find that several platforms with differing capabilities will be developed and chosen to fill the Level I and II needs. Level III calls for a persistent ISR capability like the USMC Pioneer in the USMC Tier III and a penetrating capability is required in level IV.

For the USN's level III, the persistent UAV of choice is the Global Hawk platform. Level III calls for sensors to be modified for maritime specific use while also utilizing a land based launching facility with staggered surveillance covering a 2,000 km area with persistent coverage and centralized operational control at one main operating base in CONUS.[4] Global Hawk High Altitude Long Endurance (HALE) UAVs have many uses in the maritime environment since they typically have greater than a 24 hour endurance. A set of three Global Hawks could provide continuous coverage over a 2,000 km area without tanker support while it detects, tracks and identifies surface ships from outside the range of most surface-to-air missile systems.[5] This would serve as the eyes and ears of the operational commander executing scheduled surveillance missions with support from UAVs in the other levels as well as other ISR assets.

The USN or BAMS Level IV plan calls for a “penetrating UAV” which is designed as a technical delivery system that can penetrate and survive a high threat environment and employ weapons. This UAV could be land based or could be carrier based but will still need some further research and development for carrier operations. The Navy Unmanned Combat Aerial Vehicle (UCAV) or (UCAV-N) has been identified for this role and it was originally developed as a “carrier-based, fast jet, unmanned strike and reconnaissance aircraft that can conduct penetrating surveillance, suppression of enemy air defenses (SEAD) and strike missions.”[6] The Office of Naval Research and the Defense Advanced Research Projects Agency (DARPA) are leading the research and development programs for a joint penetrating UAV for the USN and the USAF. The frontrunners for the UCAV-N are the Boeing X-45 and the Northrop Grumman X-47 with initial operating capability expected around the end of this decade.[7] The carrier based UCAV-N is very ambitious desiring a 1,000 nm strike radius from an airframe about the size of an F-18 with one third the cost of the USN Joint Strike Fighter and half the operating costs of the F-18. The UCAV-N desires to employ around 1,800 kg of Joint Direct Attack Munitions (JDAM), BLU-109 penetrating munitions or Small Diameter Bombs (SDB).[8] Level IV UAVs are seen as beefed up and higher technology versions of existing UAVs with some research and development required. Air refueling is a possibility and a solution for the new tailless design with resulting decrease in directional control that has further increased the difficulty in operating in the carrier environment. The real advances needed though are for the smaller UAVs in development for Levels I and II.

The Level I UAV calls for a small tactical UAV that has a plethora of possible contract winners including Scan Eagle, Silver Fox, Wasp, Coyote and the USMC Tier I winner Dragon Eye. Technical data for these UAVs are in Appendix A. These UAVs all have distinct capabilities and could augment the on-scene maritime commander by launching an on-demand ISR asset in the form of a tiny UAV. This could be in the form of a handheld, disposable rotary-wing UAV with a camera capability up to a fixed-wing UAV with EO/IR capability launched from the deck of a ship that recovers on the deck, in the water or by some other means. The exact performance criteria and desired capabilities for the small tactical level UAV are still undefined. I suggest that several Level I UAVs be fielded according to the differing capabilities required by naval platforms.

The Level II "tactical" UAV has a more finite plan and has been designated to be filled by Northrop Grumman's RQ/MQ-8 Fire Scout. This system recently moved into the final stages of systems development and demonstration. [9] The Fire Scout started as a modified Schweizer 333 light, three bladed helicopter and now has evolved into a four bladed helicopter with over twice the endurance of the initial variant. Technical data on Fire Scout is in Appendix A. The Fire Scout can perform missions comparable to what the Pioneer performs, but also has the capability to launch and recover from a ship. This shipboard requirement drove the UAVs to move from level III and IV assets that were fixed-wing and designed for carrier operations to new solutions. The rotary-wing capability seemed to be the best fit. The next step in the process was to develop new capabilities for the level I and II systems.

Current UAV Uses and Capabilities

The most common UAV uses have traditionally been ISR. Their capabilities have steadily increased to provide greater endurance, larger coverage area, instant feedback through pictures or live video, and provide a decreased risk to human life. The current demand for persistent ISR capability is understood throughout the services. Admiral Mike Mullen in his 2006 fleet guidance said that "in every warfare area [he wanted] to create a persistent view of what's going on there."[10] The demonstrated capabilities of UAVs have fed the concept of network-centric warfare and have created an awesome tool for operational commanders to attain the persistence they desire. The Level III UAV fulfills this persistent requirement for the Joint Force Commander with a joint UAV such as Global Hawk. These demonstrated capabilities along with advancements in technology show we can do more. Technology is allowing traditional longer-endurance platform capabilities to transfer capabilities such as synthetic aperture radar (SAR), and electro-optic/infrared (EO/IR) sensors to the tactical UAVs.[11]

Currently, all services have their own UAV programs. The U.S. Army chief of acquisition, Claude Bolton, realizes the potential resident in UAVs and feels that "the more we use these the more we want and the more ideas we have for using these better in the future." [12] The lessons learned from the ongoing Global War on Terror (GWOT) along with the consistent advancements in technology have driven the quest for even more utilization of UAVs. The Army and the Air Force currently have several dedicated platforms for their tactical UAVs designed for quick response type missions. The U.S. Army uses a hand launched General Atomics "I-Gnat" which performs reconnaissance in front of supply convoys and the USAF uses Predators for close air support.[13] The USMC currently employs Scan Eagle for close-range surveillance of potential targets and trouble spots providing EO and IR sensors as well as communications relay capability. The Scan Eagle has flown over 3,600 hours in Iraq supporting the II MEF. [14] There is an apparent shift toward UAVs that can move with forces and are owned and controlled by these forces to be employed on an as needed basis. The trends are also evident that UAVs are becoming smaller as technology allows smaller payloads with more capability.

The distinctive characteristics of UAVs that are appealing to the maritime environment are numerous. UAVs are normally smaller and lighter than manned aircraft.

They normally occupy less deck space and need less fuel to operate. The downfall though has always been that they require Vertical Take-Off and Landing (VTOL) if not operating on a carrier.[15] Most helicopters have lacked the desired range needed for persistent ISR coverage, but give an avenue to land on a ship. Land-based UAVs are therefore the best persistent ISR answer for blue-water naval operations in Level III. Existing armed UAV platforms like Predator allowed the concept development of a penetrating requirement of Level IV to have a clear vision and research and development are funded. The current littoral warfare arena lacks an on-demand surveillance and a fire-support targeting capable system.[16] The retirement of the U.S. Navy's S-3 leaves no organic surveillance against surface targets. Level I and II UAVs could fill this role until a level IV UAV is operational.

The regular use of smaller, more tactical UAVs from ships is closer to full implementation. Initial efforts for maritime UAVs were centered on larger fixed-wing UAVs such as Global Hawk or Predator type platforms. Sheer range alone allowed these platforms to avoid the problem of launching and recovering at sea. The future emphasis is on currently less capable, but much more flexible rotary wing UAVs that will only increase in capability over time as technology continues to advance. Rotary wing UAVs will allow on-demand UAV capability from battle groups or individual vessels.[17] The US Navy currently uses the Neptune UAV deployed on fast attack boats. The system can be launched from these boats and recovered by landing on the water. The Neptune storage container serves as the launcher and the UAV construct displays concept designs that will exponentially change how we think about UAVs. The Neptune's engine and avionics are placed above the waterline and the airframe is sealed for flotation as well as providing corrosion/water intrusion protection.[18] This advancement will allow water retrieval. Another UAV in use by the USN is the small fixed-wing Boeing Scan Eagle. This UAV is launched from a pneumatic catapult and is recovered by flying into a single line that is suspended about 50 feet over the water. The Scan Eagle has been employed by the Expeditionary Strike Group providing persistent ISR and on-demand oil platform security in the Persian Gulf tallying over 1,600 hours in about 6 months of use during 2005 with successful launch and recovery from LPD, LSD and HSV naval vessels.[19]

Applicable Maritime Research and Development

Several techniques for adapting UAVs to shipboard operations have been under development for many years. The Pioneer UAV attempted recovery in a net on the stern of battleships; a parafoil system was tested by Developmental Sciences; and Lockheed Martin tried a VTOL lift system. All of these early attempts to adapt UAVs to maritime use have been in an effort to meet the needs of the tactical commander. Shipboard operational concept advancements brought these concepts closer to realistic capabilities. So what is on the horizon?

The Littoral Combat Ship (LCS) is a unique shift in design and operational employment for the US Navy. The LCS is a high speed littoral water ship that will utilize helicopters, surface vehicles, submarine vehicles and UAVs as its offensive weapons.[20] The identified gaps that the LCS is designed to fill through UAVs are shallow-water mine warfare, anti-surface warfare (ASuW) and anti-submarine warfare (ASW).[21] UAVs will be utilized for detecting mines, enemy submarines and small boat attacks in areas such as choke points, where US submarines cannot operate.[22] The UAV's main contribution here will be electro-optical searches for mines in the surf zone. Other potential uses considered are ASW through sonar along with manned helicopters and WLD-1 mine hunters. The ASuW role could also be performed by Fire Scout which can carry Advanced Precision-Kill Weapons System (APKWS), essentially a laser-guided version of the 70 mm rocket.[23] Another option would be for the UAV to fix the target via EO/IR sensors and a Non-Line-of-Sight Launch System (NLOS-LS) missile launcher on the LCS could fire a missile as the UAV designates the target.[24] These are just a few of the concepts being developed.

Boeing's Phantom Works is researching several models of the DARPA-sponsored Canard Rotor-Wing (CRW) design where the craft takes off and lands in a rotary wing manner with assistance from jet exhaust. After airborne, the jet exhaust switches to an aft nozzle and the rotary wing motion stops until needed again in the recovery phase at landing. This gives the CRW the capability to take off vertically, fly at jet speeds and altitudes and then recover as a helicopter would without the normally much larger engine required in a jet-powered VTOL designed aircraft.[25] This capability brings UAVs closer to conquering the hardest problem of launch and recovery from a naval surface vessel. This concept also provides speed of a fixed-wing platform which allows a possible escort role.

The United States is not the only country delving into UAV research and development. An Israeli company, Elisra, is developing a broadband, target-quality electronic surveillance measures (ESM) system allowing on-board target processing versus the older ground-based computer interface required for processing.[26] Israel Aircraft Industries (IAI) has been developing a "light" line of UAVs, called I-View, with a modular system concept that calls for a smaller logistical footprint utilizing three sizes of vehicles that are interchangeable and share common avionics software.[27] The payloads and sensor packages can be modified to suit the needs of the user depending upon the capability needed for the mission and also the duration required for the sortie. The I-View also has advanced concepts of a catapult launch system and a powered parafoil recovery allowing a very precise landing which will be required on naval vessels.[28] Israel has significantly expanded their UAV roles over the past few years, especially since they have been involved in consistent conflict with the Palestinians. Israel's Navy has significantly upgraded their maritime radar enabling several operational modes to allow automatic tracking of targets, classification of targets with inverse synthetic aperture radar (ISAR), wide area and high-resolution imaging for littoral area surveillance and airborne capability for air tracks and weather modes.[29] Transferring these capabilities to USN UAVs has definite maritime potential as the USN will probably conduct similar operations in the GWOT. Another international researcher, Australia, has developed an indigenous UAV, MIRLI, which meets their requirement for a broad-area surveillance system for detection of surface vessels in their vast maritime approaches. This system currently has the capability for surveillance, communications relay, with sensors such as synthetic aperture radar (SAR), IR, EO, ESM, data link, and next they are trying to deploy sonobuoys as well as perfect their VTOL capability.[30] Again, transferring these capabilities to USN UAVs will enhance our ability to flexibly project power and maintain maritime awareness.

Future Maritime Uses

Along with the current research and development efforts that are constantly improving UAV capabilities, there are some programs that display potentially significant leaps in future maritime use for the tactical Level I and II platforms.

The first significant area is under the network-centric warfare (NCW) concept of forces that share information through collaboration and technical interfaces. Tactical Control System (TCS) and Tactical Common Data Link (TCDL) are a control system and data link sharing system, respectively, which have enabled massive leaps in physical control and information sharing capability of our UAV systems as well as data link sharing among active naval aircraft.[31] Not only is live video possible from thousands of miles away at an operations center, video and targeting data can be data-linked to a laptop computer. In a similar venue, Northrop Grumman's Global Hawk has successfully displayed the capability to employ Advanced Information Architecture (AIA), which allows forces to use hand-held devices to view almost real-time imagery of the target area with the capability to transmit to other users.[32] The information sharing of these systems will allow access for linked naval assets to view a common operating picture. The potential flexibility that exists for physical control allows transfer of control to a control station onboard a ship, an airborne platform or to a SEAL team.[33] Also, real time target information can be relayed to a control station onboard a naval vessel, to a submarine or directly to naval aircraft from the tactical UAV. This will allow faster prosecution of targets through providing precise target data where employment of weapons can be performed by various assets. The UAV provided target data can be utilized by an F-18 Hornet to drop a precision guided bomb, it may be relayed to a destroyer that launches an over-the horizon cruise missile, it may be relayed to a SEAL team for on the spot decisions for a direct action mission, or it may go directly to the Destroyer Squadron performing surface escort. These capabilities can be gained by launching a Level I or II UAV directly from a navy surface ship.

Another significant area is arming the tactical UAV with weapons. Arming Level I and II UAVs could allow the tactical level commander the ability to launch an organic UAV to strike a target. The network centric warfare concept uses multiple sources for feeding target information to the "shooter" or "trigger puller." The tactical UAV operator could then take the "find" and "fix" pieces from a persistent ISR asset and finish out the "target" portion of the kill chain by employing weapons. This capability to strike with a UAV will definitely be beneficial when there are no land based armed UAVs in the area, a quick response time is needed, and the visibility around the carrier is below minimums to launch manned aircraft. The tactical UAV can be launched from the LCS and becomes the shooter with dwell time to wait for weather conditions to recover on the ship. There are many more instances where the tactical UAV will be required to launch at a moments notice to handle the initial “find” and “fix” phases of the kill chain for another asset to prosecute the attack and kill the target.

Arming the Fire Scout is in the plans for both the Army and the Navy. Hydra 70 mm rockets have already been tested and a plan to “advance to some other more precise weapon” like the Hellfire missile is in the works.[34] This would greatly enhance the capability of the kill chain to go after “targets of opportunity” with a precision weapon capability.[35] The anticipated missions for the USN could include anti-surface warfare by detecting, identifying and attacking surface crafts as well as anti-submarine warfare and counter-mine operations.[36] With the V-22 Osprey becoming operational, a possible use for UAVs would be armed escort with various air-to-ground munitions including the 70mm Hydra rockets or precision weapons such as the APKWS or the Joint Common Missile.[37] Escort roles will drive capabilities such as cruise speeds; therefore only one Level II UAV (Fire Scout) may not be the best solution. Another armed UAV is Boeing’s “Little Bird,” which is currently on track to perform counter-mortar operations by detecting, locating, zooming in on the flash location and then being capable of engaging the target with Hellfire or Viper Strike weapons systems.[38] They are also looking at an anti-improvised explosive device (IED) role through sensors and jammers.[39] This capability could also be used by a Level I or II UAV launched from a maritime asset in littoral areas. Testing of Little Bird has also been successful as a communications relay platform covering a 400 km area from an altitude of 15,000 feet.[40] Here is another possible maritime use as communications relay from a SEAL team through the UAV to a submarine or surface vessel if terrain does not allow line of sight or if satellite communications is not available.

In addition to weapons and sensors, possible uses for Level I and II UAVs are to resupply isolated units with ammunition or medical supplies.[41] How about a supply drop to a SEAL team? The 160th Special Operations Aviation Regiment (SOAR) estimates that 80 percent of their missions are for re-supply and this is definitely a role that would diminish the need for ground supply convoys, increasing their re-supply capacity, decreasing their exposure to threats such as ambushes and IEDs and giving vital surveillance and reconnaissance to special operations forces.[42] If UAV payloads could handle missions like resupply of troops, I propose the following possible maritime uses for tactical UAVs. One possible use is dipping sonar where acoustic data could be relayed directly to the ship. Another potential use is to equip a UAV with a magnetic anomaly detector to perform ASW missions if a US submarine is not available. Active radar flooding an area is always a distraction to enemy submarines and could be a deterrence method employed by a UAV. Persistent coverage of heavy maritime traffic areas such as straits or harbors is also a capability a Level I or II UAV could augment if a Level III asset is not available. These heavy traffic areas often have numerous small crafts that UAVs may assist in tracking. Therefore, maintaining a recognized maritime picture and increased situational awareness. A surface escort role is definitely possible for UAVs as USN vessels transit straits and choke points. Unknown ship spills could be evaluated by UAVs with chemical and biological detectors keeping US sailors at a safe distance from a possibly contaminated area. Another possible use would be to install signals intelligence (SIGINT) equipment onboard UAVs that could relay to a shipboard listening station. A submarine launched SIGINT UAV could give covert forward presence and gain desired greater battle space awareness. What if the submarine needed to launch a Tomahawk missile and no satellite or Level III UAV coverage is available? You could use the organic UAV to either confirm target data, or launch after the Tomahawks to give timely battle damage assessment (BDA). These are all possible UAV uses that show there are many doors waiting to be opened, especially for the submarine launch capability.

Admiral Mullin realizes that we need undersea warfare and that a combined effort including various UAV strategies is needed from surveillance to detection and kill.[43] The best potential to fill a much needed organic capability for over-the–horizon communications and surveillance is the plan for submarine launched and recovered UAVs. The demonstrated capability by Scan Eagle in exercises like Giant Shadow, have proven that Level I or II UAVs can support cruise-missile-firing submarines as well as interface with SEAL teams.[44] There is still a long way to go though on submarine launched UAVs. Northrop Grumman has demonstrated the Stealthy Affordable Capsule System (SACS) which launches the UAV in a capsule from the vertical Tomahawk tubes on the SSGN or from a torpedo tube. Another example is the Sea Sentry which is stowed in a container on the submarine's mast from where it is released. SACS and Sea Sentry require small UAVs to be stored in containers and the UAVs chosen must be expendable.[45] The best potential to meet this aim though is being developed by DARPA under their Cormorant submarine launched UAV program. Like the SACS system, DARPA is developing the capability to launch a capsule containing a UAV from a Tomahawk tube and it will be recovered by a mechanical arm that attaches a cable and draws the UAV back into the tube.[46] Once inside the tube, it can be refurbished, refueled and relaunched numerous times.[47] There are many engineering challenges though with structural limits, weight requirements, crush loads and drop loads, that all need to balance out to allow the UAV the capability to survive pressure changes as it rises, be light enough to fly efficiently, withstand pseudo crash landing in the water and then be brought back down under increasing pressure to the depth of the submarine.[48] In addition to engineering and research and development issues for Level I and II UAVs, there are employment issues that need to be addressed for these systems. For example, UAVs used as communications relays or for live video feed will use the network-centric warfare concept which may have some drawbacks.

Contingencies/Stumbling Blocks

Expanded global connectivity has decreased the time line to the point of enabling senior leadership to see a live feed and gives real-time situational awareness to operational commanders. This potentially has a negative micromanagement effect with a "reach-forward" approach. The often mentioned 8,000 mile long screwdriver in the hand of higher-level leaders or their staffs may occur as the tactical commander's UAV video feed is seen above his level.[49] UAVs shortening the kill chain due to the speed at which targets can be generated and attacked can "blur" the distinction between the command and control piece and the execution piece.[50] This has caused a distinct creeping centralization of command and execution as the upper level commander reaches forward and controls the battlefield decisions. This will probably be more prevalent in the future as there has been a trend away from linear battles and scripted plans to a more fluid and reactive operational environment with fleeting opportunities to engage a target of opportunity by employing a tactical UAV. The move to more centralized control and execution may inhibit the on-scene commander from being able to take the initiative if they have to wait for a higher level commander to make a decision on whether to engage or not from the live UAV video feed.

Another potential problem area that will need to be addressed in the immediate future is UAV airspace management and architecture in the joint arena.[51] The rate of increase in UAV use has sky-rocketed over the last 10 years. The introduction of more UAVs into each theater of operations only clouds the air picture that sometimes is congested to begin with.

The existing airspace management problems will only increase with the introduction of these additional vehicles into already congested airspace. There have been many incidents of near mid-air collisions over the past few years between UAVs and fixed-wing aircraft and even a few with rotary-wing aircraft. Future increased use will require better airspace management and coordination for safe and effective flying operations. This is not a major hurdle, but the issue will need to be addressed in the form of doctrine developed for UAV use as well as organizing and training implementation plans.

The final stumbling block as UAVs develop is the separate development programs being pursued by each service. There has always been much debate on joint programs for weapons systems. What looks good at the beginning of a program for all involved may soon show that the end result in capability may satisfy one service but may not meet the needs of another. Changes often occur after initial capabilities requests and joint development could have a loser. With service concerns for cost and interoperability issues, the Joint Unmanned Combat Air Systems (J-UCAS) program was cancelled in late 2005. This decision to cancel the program resulted in the USN reallocating 1.8 billion dollars towards a new carrier-based UCAV while the USAF similarly re-invested 1.9 billion into an autonomous airborne refueling capability and other programs.[52] A similar decision to terminate the U. S. Army's Unmanned Combat Armed Rotorcraft (UCAR) program saw their funding diverted into manned helicopter improvements and concept design studies for heavy lift helicopters.[53] These decisions had different ends for money originally invested in UAV development. This is only one instance that displays that service needs will influence the unmanned vehicle community in differing ways. There are also distinct differences in capabilities that are required for each service. I feel as we approach the criteria of Level I and II UAVs that separate and distinct requirements will be evident at the operational and tactical levels as well as unique to each theater and service.

Conclusion/Recommendations

The USN needs a better road map for tactical UAVs to exploit emerging capabilities and utilize them in maritime roles which will ensure Maritime Domain Awareness. There are many possibilities for Level I and II UAV platforms. These various UAV platforms have distinct capabilities that complement battle space management through the various sensors that they can employ. The range of possible UAV maritime missions can enhance current missions performed by manned aircraft and show the promise to fill voids such as ASuW caused by retired aircraft. Level I and II UAVs increase situational awareness and will increase the flexibility and capability of the kill chain for operational level commanders by launching on-demand and instantly providing video or communications as needed. Tactical UAVs will assist with gaining and sharing battle force access for naval and joint forces in areas such as littoral spaces where access is limited. They will increase the on-demand capability to gain ISR information and allow the flexibility to project power. The USN needs a better road map for these Level I and II UAVs to fully implement emerging technology into maritime roles.

USN Level I and II UAVs will impact the operational level of warfare through expanded capabilities. The military challenges we will face in the future call for increased capability in access challenged areas. For the USN, this looks to be future operations in littoral areas. Tactical UAVs will assist in various maritime roles such as escort, ASW and ASUW. They will increase the on-demand capability to gain ISR and allow the flexibility to project power if needed directly from UAVs or through the UAV acting as a targeting fixer for another platform to employ weapons effects. These tactical UAVs will allow supporting capability to naval and joint forces such as SOF and forward deployed units outside of the reach of persistent long-dwell assets. The UAV will allow the collection of tactical information and push this information through various communication sources to unit, national and theater commanders. Air Force Major General Joseph Stein, Director of Aerospace Operations at Headquarters, Air Combat Command in 2003 said the target kill chain is getting better with time, but we are,

> "…still looking forward to a 'quantum leap' in overall UAV systems and control capabilities. The services need to capitalize on the success of Predator and Global Hawk and focus on the operational potential of UAVs, the future of which includes systems such as the Predator B, the unmanned Combat Aerial Vehicle (UCAV) and possibly mini- and micro- UAVs."[54]

It is exceptionally clear from an operational commander's perspective that the operational level gains from tactical UAVs are understood and we should diligently pursue discovering new ways and means to develop this emerging capability.

NOTES

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Appendix A
Unmanned Aircraft Systems Diagrams

Sources:
Unmanned Aircraft Systems Road Map 2005, U.S. Government, Office of the Secretary of Defense, Washington DC, (accessed 21 October 2006).
http://www.fas.org/irp/program/collect/uav_roadmap2005.pdf ,
Pages Used: page 17 Cormorant, Page 9- Firescout, page 14 Global Hawk and BAMS, Page 11- J-UCAS, page 20- Neptune, page 28- Scan Eagle and page C-3 Figure C-1 Global Hawk Communications Architecture.

Excerpt from page 17

2.2.3 Cormorant

User Service: DARPA
Manufacturer: Lockheed Martin
Inventory: 0 Delivered/TBD Planned
Background: The Cormorant project is currently conducting a series of risk reduction demonstrations for a multi-purpose UA that is "immersible" and capable of launch, recovery, and re-launch from a submerged SSGN submarine or a surface ship. Such an UA could provide all- weather ISR&T, BDA, armed reconnaissance, or SOF and specialized mission support. In particular, the combination of a stealthy SSGN submarine and a survivable air vehicle could introduce a disruptive capability to support future joint operations. If the current demonstrations are successful, follow-on efforts could involve building an immersible and flyable demonstrator UA.

Characteristics:

	Cormorant		Cormorant
Length	19 ft	Wing Span	16 ft
Gross Weight	9,000 lb	Payload Capacity	1,000 lb
Fuel Capacity	2,500 lb	Fuel Type	JP-5
Engine Make	TBD	Power	3,000 lb thrust

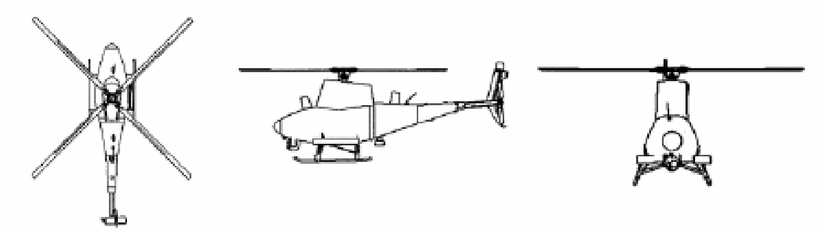
Performance:

Endurance	3 hr	Max/Loiter Speeds	0.8M/0.5M
Ceiling	35,000 ft	Radius	400-500 nm
Takeoff Means	Rocket-Boosted	Landing Means	Splashdown

Excerpt from page 9

2.1.6 RQ-8A/B Fire Scout

User Service: Army and Navy
Manufacturer: Northrop Grumman
Inventory: 5 Delivered/192 Planned



Background: The Fire Scout Vertical Take-Off and Landing (VTOL) Tactical UAV (VTUAV) program is currently in EMD. Five RQ-8A air vehicles and four ground control stations are now in developmental testing. Over 100 successful test flights have been accomplished demonstrating autonomous flight, TCDL operations, Multi-Mission Payload performance, and ground control station operations. The Army selected the four-bladed RQ-8B model as its category IV UA for its future combat system (FCS) in 2003. Planned delivery for the first two prototypes is in 2006. The Navy has selected the RQ-8B to support the Littoral Combat Ship (LCS) class of surface vessels. *http://uav.navair.navy.mil/.*

Characteristics:

	RQ-8B		RQ-8B
Length	22.9 ft	Wing Span	27.5 ft
Gross Weight	3,150 lb	Payload Capacity	600 lb
Fuel Capacity	1,288 lb	Fuel Type	JP-5/JP-8
Engine Make	Rolls Royce 250-C20W	Power	420 shp
Data Link(s)	LOS C2	Frequency	Ku-band/UHF
	LOS Video		Ku-band

Performance:

Endurance	6+ hr	Max/Loiter Speeds	125/0 kt
Ceiling	20,000 ft	Radius	150 nm
Takeoff Means	Vertical	Landing Means	Hover
Sensor	EO/IR/LDRF	Sensor Make	FSI Brite Star II

Excerpt from page 14

2.1.11 Global Hawk Maritime Demonstration (GHMD)

User Service: Navy
Manufacture: Northrop Grumman
Inventory: 0 Delivered/2 Planned

Background: The GHMD program is a non-acquisition demonstration program. Its purpose is to provide the Navy a multi-INT, high altitude, persistent, ISR demonstration capability for doctrine; CONOPS; Tactics, Techniques, and Procedures development; and participation as a Sea Trial 21 initiative (a part of Trident Warrior 05). In FY03, the Navy contracted with Northrop Grumman through the Air Force Global Hawk program office for the purchase of:

- Two RQ-4 (Block10) Global Hawks (2,000 pound payload) with EO/IR and SAR sensors
- Ground control/support equipment
- Engineering to include Navy changes for:
  - Maritime sensor modes software (maritime surveillance, target acquisition, inverse SAR)
  - 360 degree field-of-regard electronic support measures capability
  - Satellite and direct data link upgrades

When delivered, these two UA with sensors and ground control/support equipment will be delivered to the Navy's GHMD main operating base at Patuxent River, MD. *http://uav.navair.navy.mil.*

2.1.12 Broad Area Maritime Surveillance (BAMS) UA

User Service: Navy
Manufacturer: TBD
Inventory: 0 Delivered/TBD Planned

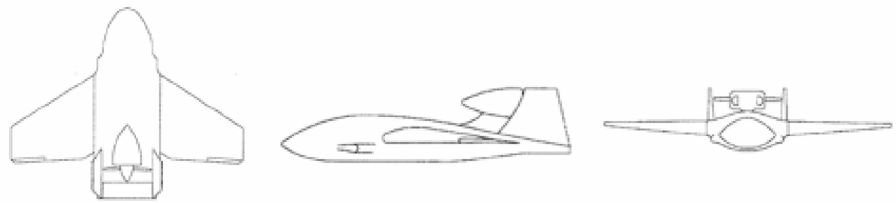
Background: The Navy is developing the BAMS UA to provide a persistent, maritime, worldwide access, ISR capability. Operating as an adjunct to the Multi-mission Maritime Aircraft, the BAMS UA will conduct continuous open-ocean and littoral surveillance of targets as small as 30-foot vessels. The BAMS UA will be unarmed, possess high endurance, and will operate from land-based sites worldwide. BAMS UAS of up to 5-6 air vehicles at each operating location will provide persistence by being airborne 24 hours a day, 7 days a week out to on-station ranges of 2,000 nautical miles. Worldwide access will be achieved by providing coverage over nearly all the world's high-density sea-lanes, littorals, and areas of national interest from its operating locations. BAMS UA will also contribute to providing the Fleet Commander a common operational picture of the battlespace day and night. Additionally, a communication relay capability will provide the Fleet Commander a 'low hanging satellite' capability, linking him to widely dispersed forces in the theater of operation and serving as a communication node in the Navy's FORCEnet strategy. *http://uav.navair.navy.mil/bams/BAMS_AUVSI_Brief.pdf*

Excerpt from page 11

2.3 SPECIAL OPERATIONS UAS

2.3.1 Neptune

User Service: Navy
Manufacturer: DRS Unmanned Technologies
Inventory: 15 Delivered/27 Planned



Background: Neptune is a new tactical UA design optimized for at-sea launch and recovery. Carried in a 72x30x20 inch case that transforms into a pneumatic launcher, it can be launched from small vessels and recovered in open water. It can carry IR or color video sensors, or can be used to drop small payloads. Its digital data link is designed to minimize multipath effects over water. First flight occurred in January 2002, and an initial production contract was awarded to DRS Unmanned Technologies in March 2002.

Characteristics:

	Neptune		Neptune
Length	6 ft	Wing Span	7 ft
Gross Weight	80 lb	Payload Capacity	20 lb
Fuel Capacity	18 lb	Fuel Type	MOGAS
Engine Make	2 Stroke	Power	15 hp
Data Link(s)	LOS C2	Frequency	UHF
	LOS Video		UHF

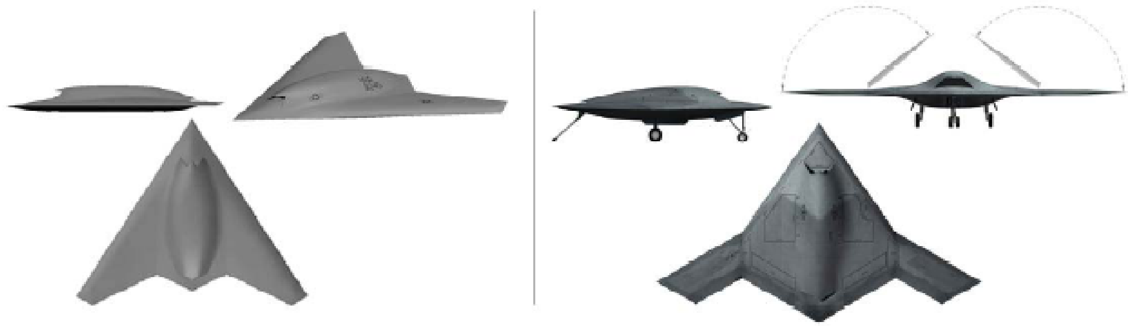
Performance:

Endurance	4 hr	Max/Loiter Speeds	84/60 kt
Ceiling	8,000 ft	Radius	40 nm
Takeoff Means	Pneumatic	Landing Means	Water/Skid/Parachute
Sensor	EO or IR	Sensor Make	DRS

Excerpt from page 20

2.1.8 Joint Unmanned Combat Air Systems (J-UCAS)

User Service: Air Force and Navy
Manufacturers: Boeing, Northrop Grumman
Inventory: 2 X-45A Delivered, 1 X-47A Demonstrated/3 X-45C Planned, 3 X-47B Planned



Boeing X-45C (L) and Northrop Grumman X-47B (R) J-UCAS Demonstrators

Background: The Air Force UCAV and Navy UCAV-N demonstrator programs were combined into a joint program under Defense Advanced Research Projects Agency (DARPA) management in FY04. First flights of the original prototypes, the Boeing X-45A and the Northrop Grumman X-47A, occurred in May 2002 and February 2003, respectively. Testing of the two X-45As continues through September 2005. First flights of the larger X-45C and X-47B models and introduction of a *Common Operating System* are to occur in 2007. J-UCAS is focused on demonstrating a versatile combat network in which air and ground components are nodes that can be changed over time to support a wide range of potential missions. The program demonstrated weapon delivery and coordinated flight in 2004. Program management responsibility is planned to transfer from DARPA to the Air Force in FY06. *http://www.darpa.mil/j-ucas/.*

Characteristics:

	X-45C	X-47B		X-45C	X-47B
Length	39 ft	38 ft	Wing Span	49 ft	62 ft
Gross Weight	36,500 lb	46,000 lb	Payload Capacity	4,500 lb	4,500 lb
Fuel Capacity	14,000 lb	17,000 lb	Weapon	GBU-31	GBU-31
Engine Make	GE F404-GE-102D	F100-PW-220U	Fuel Type	JP-8	JP-8
Data Link(s)	Link 16	Link 16	Frequency	Ku, Ka	Ku, Ka

Performance:

Endurance	7 hr	9 hr	Max/Loiter Speeds	460/TBD kt	460/TBD kt
Ceiling	40,000 ft	40,000 ft	Radius	1,200 nm	1,600 nm
Takeoff Means	Runway Carrier Option	Runway/Carrier	Landing Means	Runway Carrier Option	Runway/Carrier
Sensor	ESM	ESM	Sensor Make	ALR-69	ALR-69
	SAR/GMTI	SAR/GMTI EO/IR		TBD	TBD

Excerpt from page 28

	Silver Fox	ScanEagle	Aerosonde	BATCAM
Manufacturer	Advanced Ceramics	Insitu Group/Boeing	Aerosonde/Lockheed Martin	ARA
User Service	Navy	Marine Corps	Navy	SOCOM
Weight	20 lb	39.6 lb	33 lb	0.84 lb
Length	4.8 ft	3.9 ft	5.7 ft	24 in
Wingspan	7.8 ft	10 ft	9.4 ft	21 in
Payload Capacity	5 lb	5-7 lb	12 lb	0.09 lb
Engine Type	Diesel/Gasoline	Gasoline	Gasoline	Battery
Ceiling	16,000 ft	19,000 ft	20,000 ft	1,000 ft
Radius	20 nm	60 nm	1,000 nm	1.6 nm
Endurance	10 hr	20 hr	30 hr	18 min
Number Planned	20-30 systems	2 systems (lease)	1 system	23 systems
Number UA/System	3	8	5-8	2

Silver Fox

Background: Silver Fox is a modular UA capable of running on either MOGAS or JP fuel. The Office of Naval Research is testing its utility for ship security and harbor patrol. It has demonstrated an endurance of 8 hours and is attempting to control four airborne aircraft simultaneously. Canada's armed forces are acquiring a system for joint evaluation.

ScanEagle

Background: ScanEagle is a long endurance, low cost UA. It recently supported JFCOM's Forward Look exercises, and two systems of eight aircraft each deployed to Iraq to provide force protection for the 1st Marine Expeditionary Force (I MEF). ScanEagle carries an inertially stabilized camera turret for both EO/IR imagery. Its sensor data links have integrated Cursor on Target (CoT) capability, allowing it to be interoperable with other legacy systems and enabling the operator to integrate operations with larger, high-value UA such as Predator through the ground control station. Its Skyhook (near-vertical recovery system) and pneumatic catapult launcher allow operations from ships or from remote, unimproved areas. ScanEagle's longest endurance flight aloft is 20.1 hours. A planned version will feature improved endurance of over 30 hours.

Aerosonde

Background: Aerosonde is a very long endurance, low cost UAS. Aerosonde can carry a family of compact payloads including TV cameras, IR cameras, ESM, and jammer electronics. Aerosonde is currently operating at NASA's Wallops Island Flight Facility, at an a arctic facility in Barrow, Alaska, and at two locations in Australia. The Office of Naval Research has purchased several aircraft along with services for instrument/payload development. Aerosonde has also been selected for the USAF Weather Scout Foreign Cooperative Test.

Excerpt from page C-3, Figure C-1, Sample Global Hawk Communications Architecture.